Mestrado em Engenharia Elétrica

Processamento de Imagem

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1. **Objetivo:** Pesquisar técnicas heurísticas para segmentação de imagens. Aplicações em processamento de imagens compreendendo:
   a. Lógica Fuzzy e Agrupamento
   b. Redes neurais
   c. Heurísticas de busca
   d. Aplicações
2. **Bibliografia:**
   a. The Image Processing Handbook – John Russ. IEEE Press
   b. Artigos diversos
3. **Metodologia**: aulas expositivas e trabalhos de implementação

ROBUST IMAGE SEGMENTATION USING GENETIC ALGORITHM WITH A FUZZY MEASURE

DAE N. CHUN* and HYUN S. YANG†‡

Pattern Recognition, Vol. 29, No. 7, pp. 1195–1211, 1996
Elsevier Science Ltd

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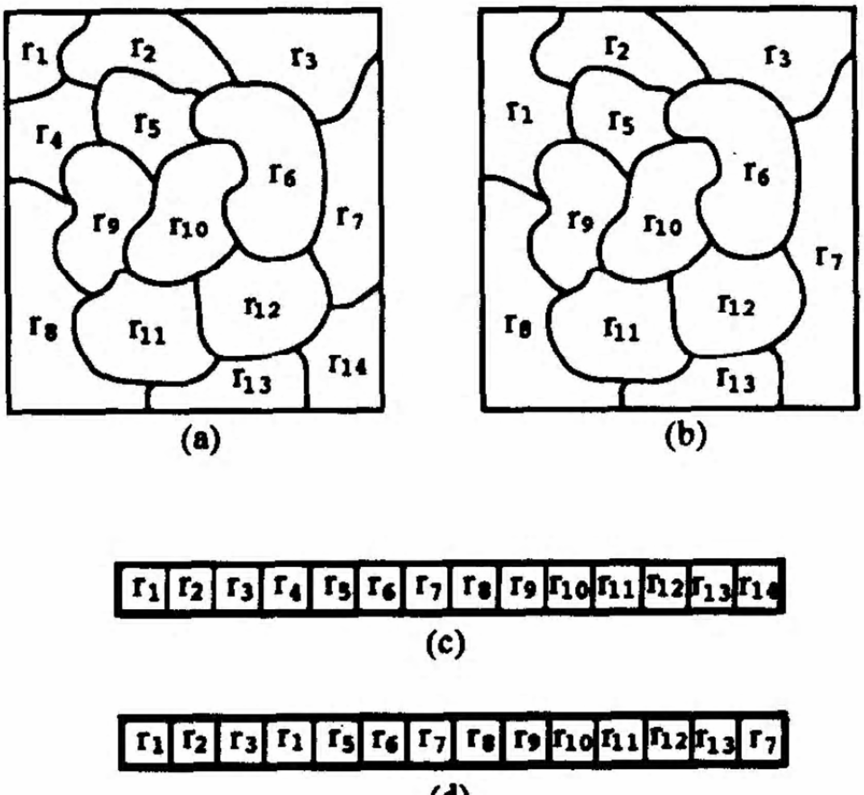
Encoding scheme of chromosome



Fuzzy fitness function

$$s_{ij} = \|m_i - m_j\|^2$$
$$c_{ij} = \sigma_i^2 + \sigma_j^2.$$
$$G_i = \frac{1}{n_i} \sum_j^{n_i} \left(\frac{s_{ij}}{c_{ij}} \right).$$

$$G = \frac{1}{n} \sum_{i=1}^{n} W_i(p_i) G_i,$$

$$W_i(p_i) = \begin{cases} \dfrac{2(p_i^2)}{\beta^2} & \text{if } \alpha \le p_i < \dfrac{2}{\beta} \\ 1 - \dfrac{2(p_i - \beta)^2}{\beta^2} & \text{if } \dfrac{2}{\beta} \le p_i < \beta \\ 1 & \text{if } p_i \ge \beta \end{cases}$$

$$|\nabla G(i,j)| = \left[\left(\frac{\partial G(i,j)}{\partial x} \right)_{ij}^2 + \left(\frac{\partial G(i,j)}{\partial y} \right)_{ij}^2 \right]^{1/2},$$

$$E = \sum_{(i,j)} \frac{\mu_{ij}(|\nabla G|)}{\mu_{ij}(|\nabla G'|)} \quad (0 \le E \le 1, |\nabla G| \le |\nabla G'|),$$

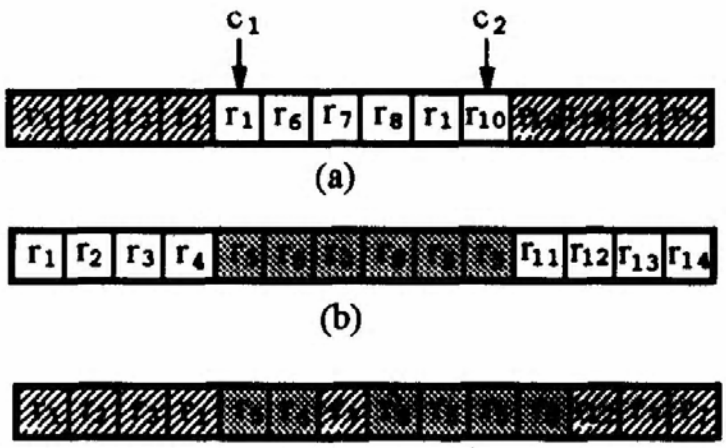
$$\mu_{ij} = \frac{d_{ij}^{2/m-1}}{\sum_{i=1}^{n_i} (d_{ij})^{2/m-1}},$$

$$d_{ij} = \frac{1}{n_{ij}} \sum_{k=1}^{n_{ij}} \|x_{ijk} - x_{jik}\|^2,$$

compact and separation G and the magnitude of the gradient *E*, i.e.

$$F = GE. \qquad (15)$$

Two-point crossover recombination operator



(a)

(b)

(c)

Procedure Two-point crossover mechanism
begin
  Randomly select two chromosomes P_1 and P_2 ($F(P_1) < F(P_2)$) by Roulette Wheel.
  if (P_1 and P_2 undergo crossover by $P_{\text{crossover}}$) {
    Select two crossover points c_1 and c_2 ($c_1 < c_2$) at random.
    for ($j = c_1, c_1 + 1, \ldots, c_2$) {
      if ($P_2[j] < c_1$ or $P_2[j] > c_2$) {
        for ($i = 1, \ldots, c_1 - 1, c_2 + 1, \ldots, n$)
          if ($P_2[i] == P_2[j]$) $P_2[i] = j$
        $P_2[j] = j$
      }
      else $Child[j] = P_2[j]$
    }
    for ($j = 1, \ldots, c_1 - 1, c_2 + 1, \ldots, n$)
      if ($c_1 \leq P_1[j] \leq c_2$) $Child[j] = P_2[P_1[j]]$
      else $Child[j] = P_1[j]$
    }
    else {
      for ($j = 1, 2, \ldots, n$)
        $Child[j] = P_2[j]$
      }
    end
    Endprocedure

Dynamic mutation operator

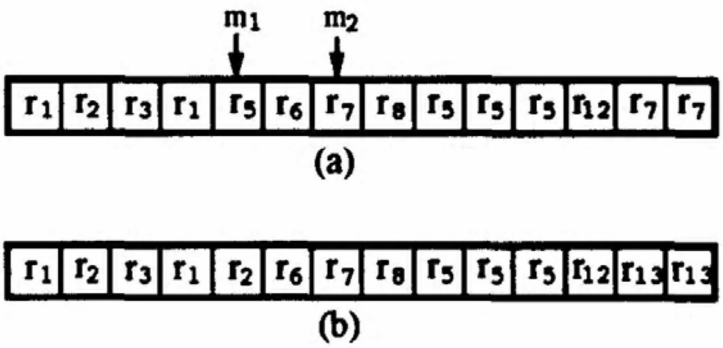


Fig. 5. New child chromosome generated by mutation operation. (a) The chromosome structure to be mutated [Fig. 3(c)]; (b) new chromosome generated by the mutation operation [the region r_5 is merged with $r_2(m_1)$ and r_7 is split from the region which is already merged with r_7, r_{13} and r_{14} (m_2)].

Procedure Dynamic mutation mechanism
begin
  Calculate the local contrast (C_i) of each gene in a chromosome I_k.
  Select any mutating gene i according to a roulette wheel sized in proportion to C_i.
  The gene i is randomly determined either to merge or to split.
  if (merging)
    Merged after selecting one adjacent region r_j with $\max_j(1/\mu_{ij})$
  else if (splitting)
    If the region is already merged by other regions, then split from the regions, otherwise skip.
end
Endprocedure

$$C_i = \begin{cases} \min\left(\dfrac{\min_j(\mu_{ij})}{\max_j(\mu_{ij}) - \min_j(\mu_{ij})}, 1\right) & \text{if } \min_j \neq \max_j \\ 1 & \text{if } \min_j = \max_j \end{cases}$$

$$\mu_{ij} = \frac{d_{ij}^{2/m-1}}{\sum_{i=1}^{n_i} (d_{ij})^{2/m-1}},$$

EXPERIMENTAL RESULTS

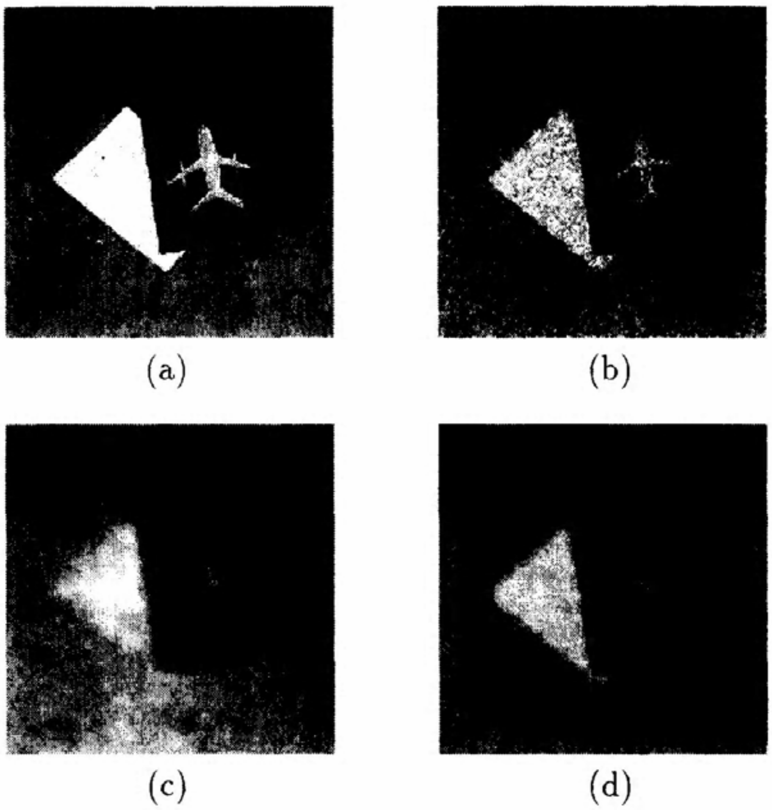
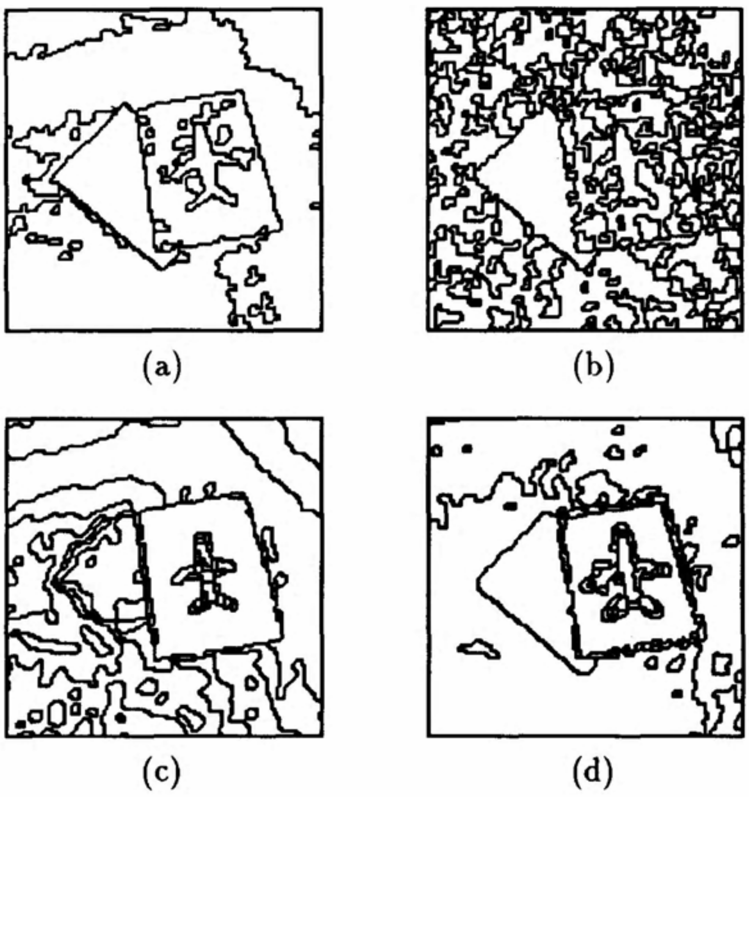


Fig. 6. Test images. (a) Original test image of the size of 128 × 128 pixels with four clear regions; (b) noisy image corrupted with Gaussian noise (deviation = 20.0, mean = 0.0); (c) spot noisy image blurred by 5 × 5 matrix from the Fig. 6(a) image; (d) blurred image by 5 × 5 matrix from the Fig. (b) image.



EXPERIMENTAL RESULTS

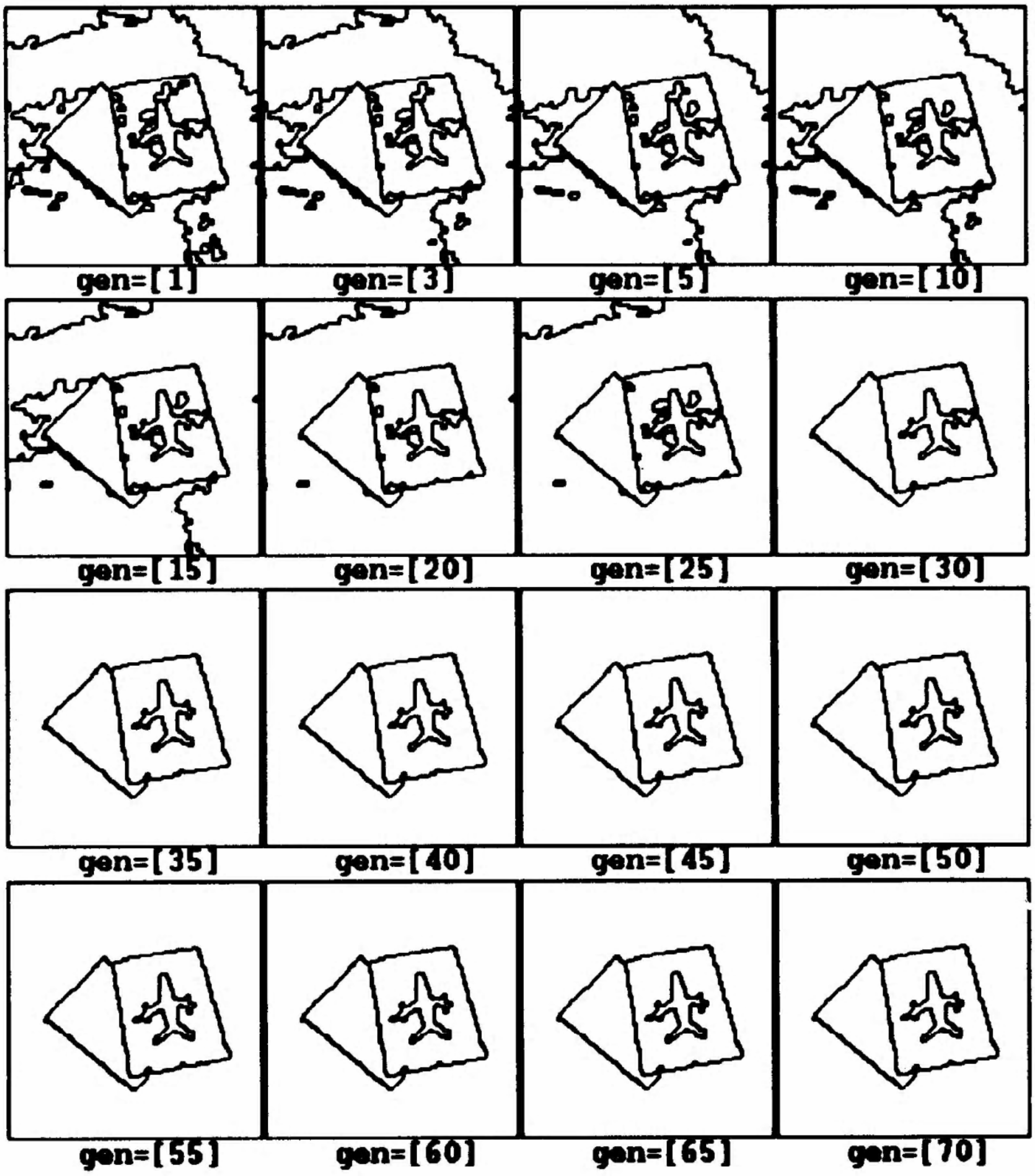


Fig. 8. The segmentation process of the original image in Fig. 6(a) during the progression of generations ($P_{\text{crossover}} = 0.2$, $P_{\text{mutation}} = 0.1$).

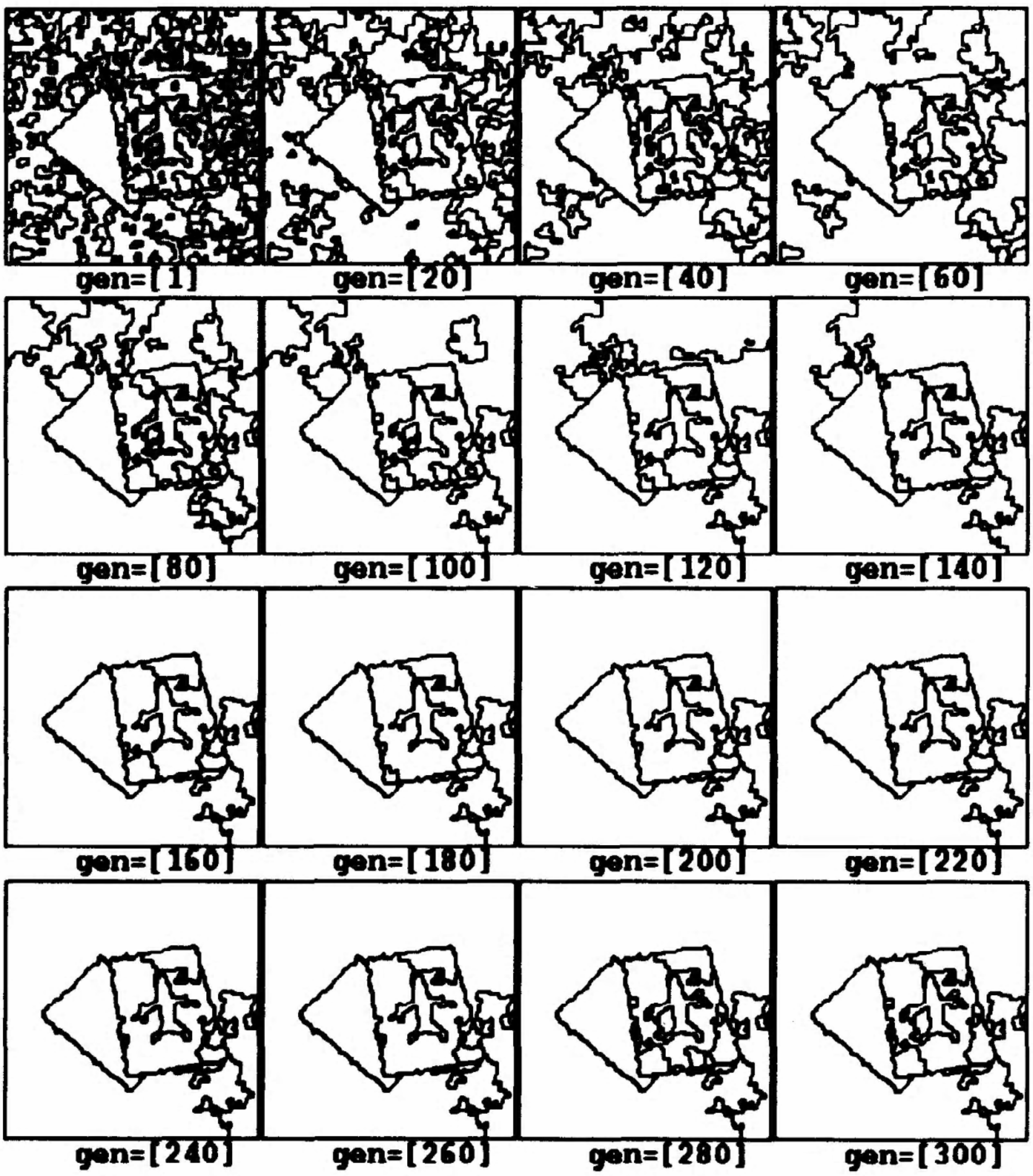


Fig. 9. The segmentation process of the noisy image in Fig. 6(b) ($P_{crossover} = 0.2$, $P_{mutation} = 0.1$).

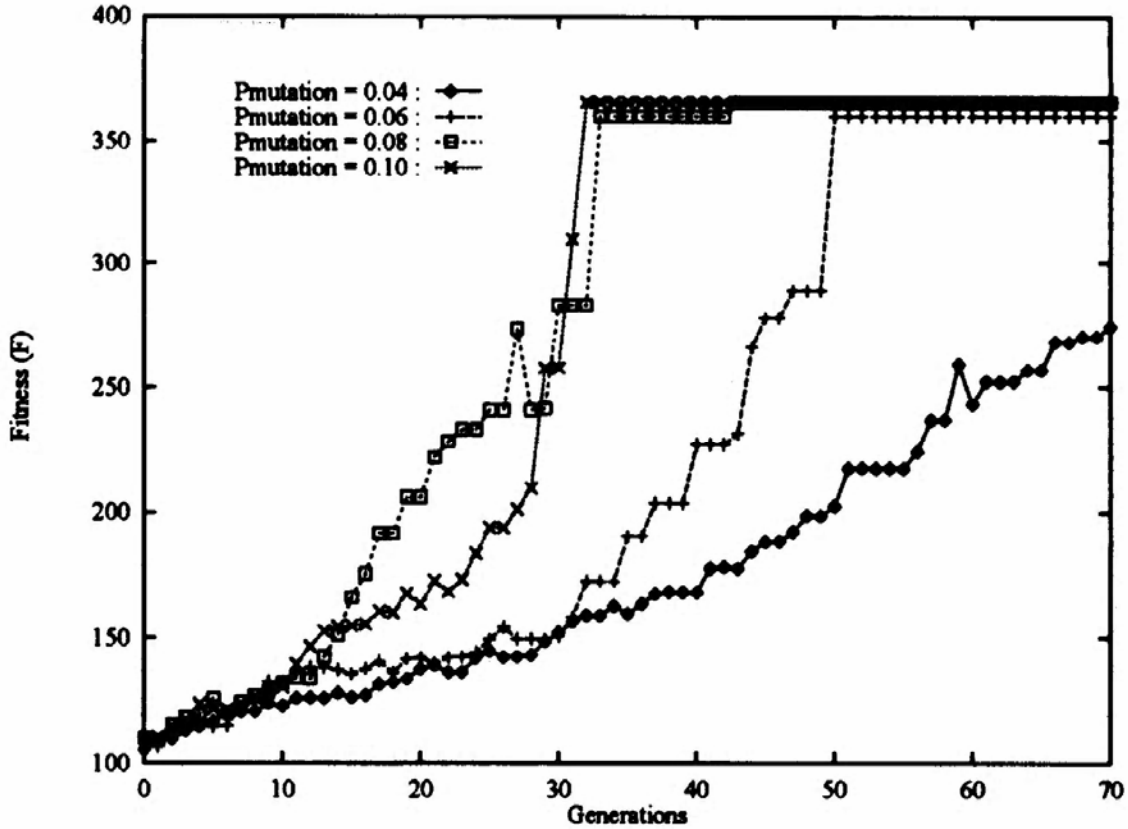


Fig. 12. Varieties of fitnesses as the mutation rate ($P_{mutation}$) about the Fig. 6(a) image.

EXPERIMENTAL RESULTS

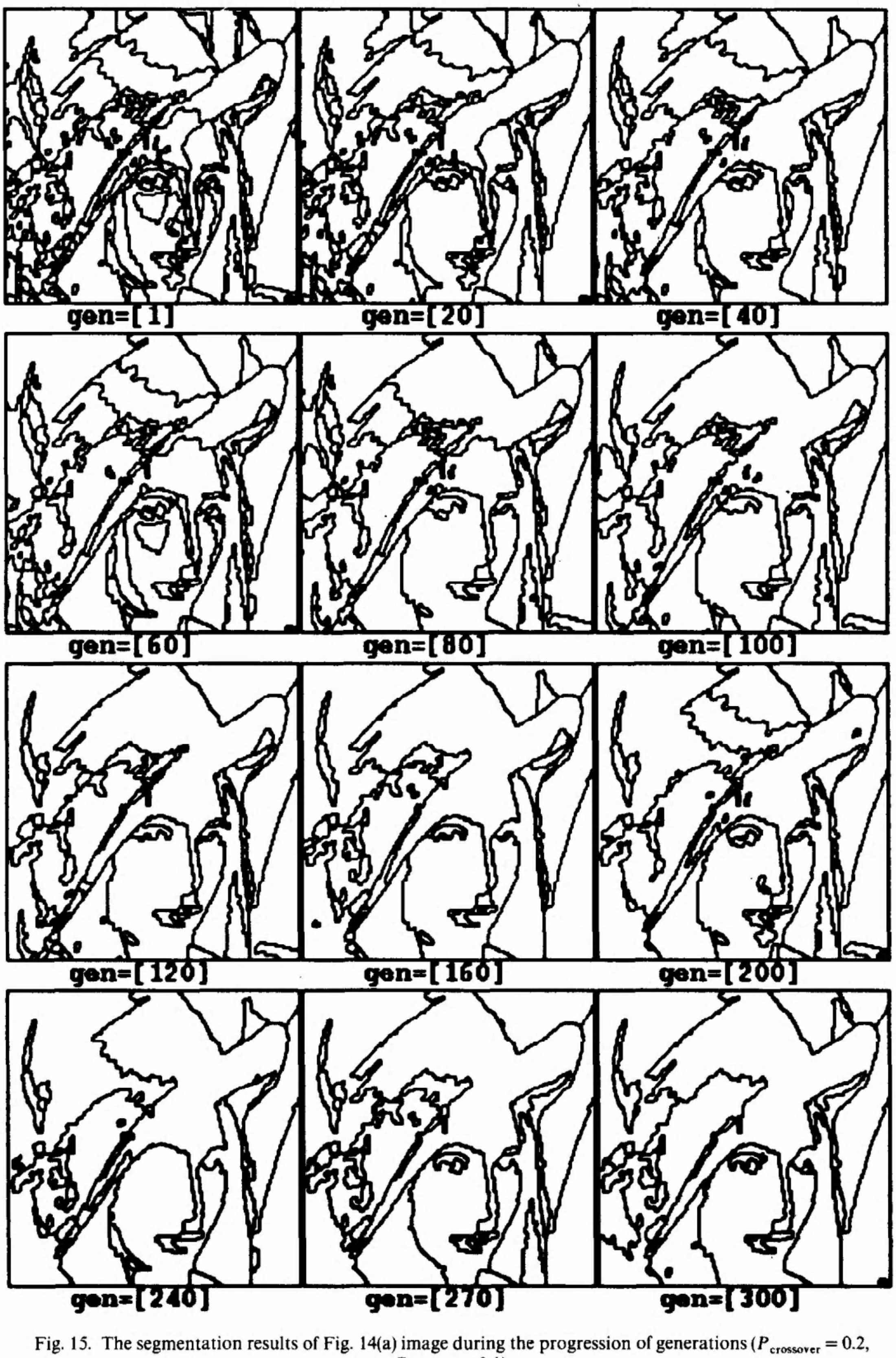


Fig. 15. The segmentation results of Fig. 14(a) image during the progression of generations ($P_{crossover} = 0.2$, $P_{mutation} = 0.1$).

A genetic algorithm for image segmentation

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The generic chromosome $\alpha_{i,j}$

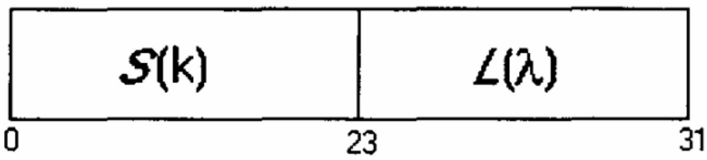


Figure 2. Chromosome representation.

$$L(\lambda) = (\frac{2^8-1}{K}) \times \lambda$$

$$S(k) = (\frac{2^{24}-1}{N \times M}) \times k$$

$$k = i \times m + j$$

The *fitness function*,

$$f(\delta) = \rho(\delta, mv_{L^{-1}(\delta)})$$

$$mv_j = \frac{\sum_{\delta \in P_j} \mathbf{X}(S^{-1}(\delta)))}{|P_j|}$$

single point crossover and bit mutation

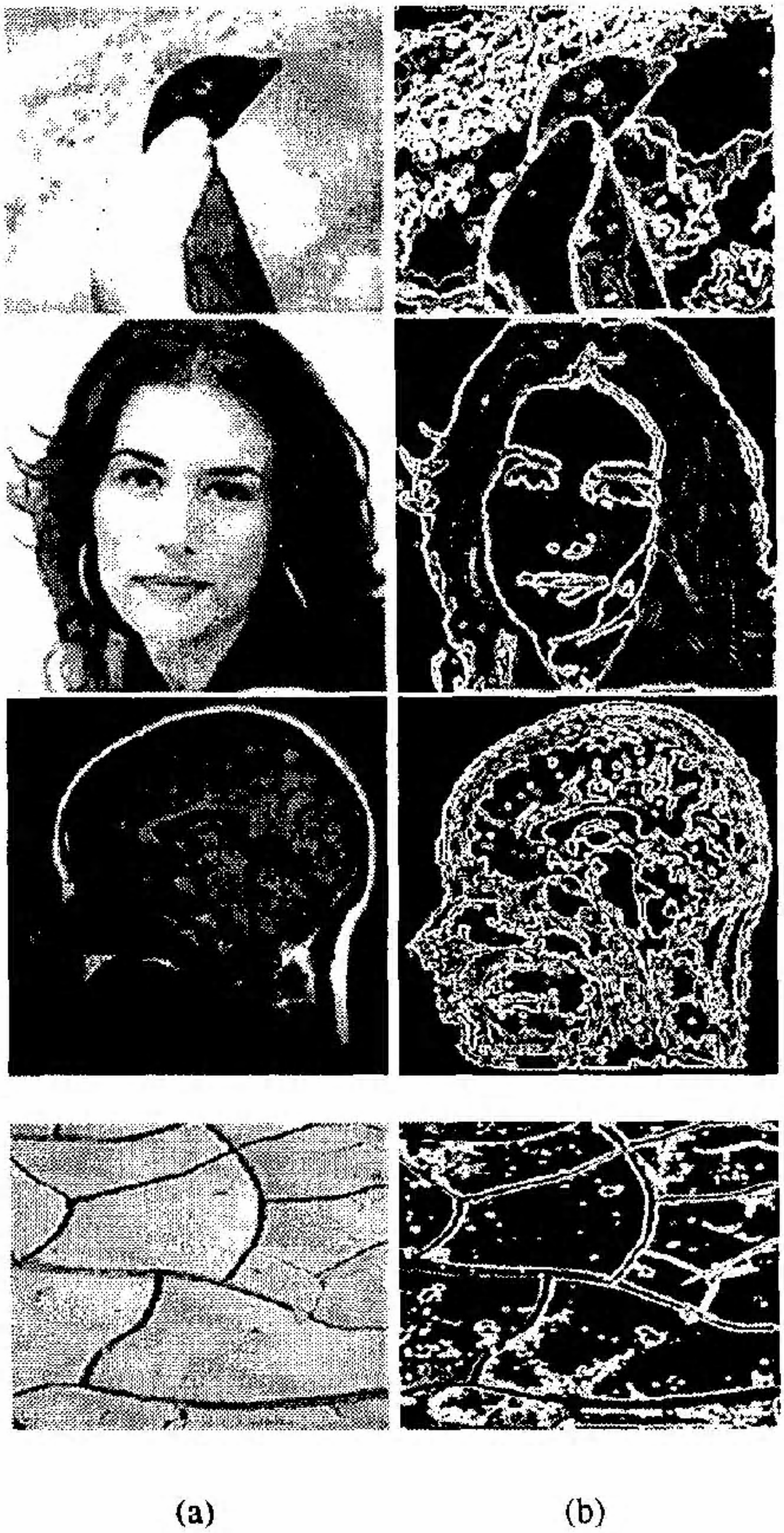
algorithm

1. *input* - Read $\mathbf{X}$ of size $n \times m$;
2. *(initial condition)* - Set up a population of chromosome $P(0) = \{\alpha_1(0), \alpha_2(0), \ldots.., \alpha_{n\times m}(0)\}$ and assign at random a label to each $\alpha_i(0)$;
3. *(genetic process)* - Apply Γ to current population $P(t)$;
4. *(selection process)* - Build population $P(t+1)$ choosing by selecting the *best chromosome* from $P(t)$ and $\Gamma(P(t))$;
5. *(set iteration)* $t \leftarrow t + 1$;
6. *(halting condition)* - If $|Var_{t-1} - Var_t| > \phi$ goto 3; else stop.

$$P(t+1) = \{\gamma_1, \gamma_2, \ldots..\gamma_{n\times m}\}$$

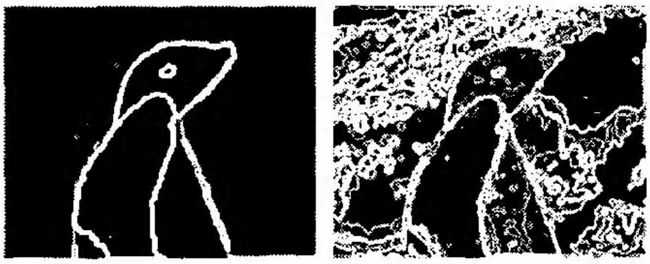
$$\gamma_r = \begin{cases} \beta_r \text{ if } f(\beta_r) < f(\alpha_r) \\ \alpha_r \text{ otherwise} \end{cases}$$

EXPERIMENTAL RESULTS



(a) (b)

EXPERIMENTAL RESULTS



(a) (b)

Figure 4. Human machine comparison: (a) human segmentation; (b) machine segmentation.

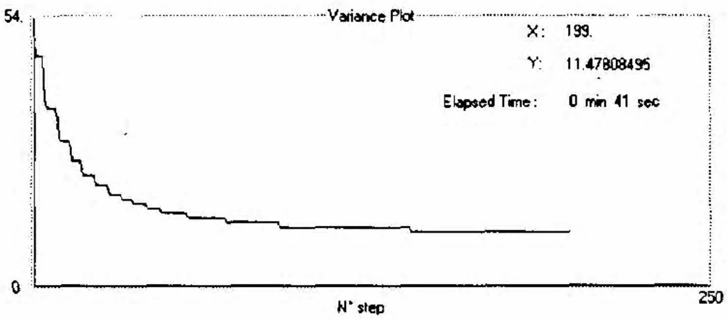


Figure 5. Example of the algorithm convergence.